Space Weather Technical Forecast

Issued on Sunday, 25 February 2024 at 13:06 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Ongoing likelihood of M-flares with a chance of X-flares due to AR3590. Chance of G1/Minor Storm intervals either late day 1 or early day 2 (25-26 Feb)

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with the largest flare peaking at C7.8 at 24/1756 UTC from AR3590 in the north-centre disc. Of the five numbered sunspot regions, and one unnumbered region, AR3590 was the source of all the notable flares and remains the largest and most complex region on the Earth-facing Sun. The region continued to show a very slow increase in areal extent, with a large but weak delta spot comprised of the strong leader spot and a strong intermediate spot. Further much smaller delta spots are also evident, including to the east of the intermediate spot, leading to some subtle complexity, despite the relatively simple east-west aligned nature of the region. No noteworthy dynamical changes occurred with the magnetic configuration of the region, and along with the limited shear across the spot, this likely resulted in the reduction of flare activity.

There were no Earth directed CMEs observed in available imagery.

Solar Wind / Geomagnetic Activity: A weak, glancing CME arrived at 24/1617 UTC, from the filament eruption on 21 Feb, however solar winds remained mostly background to slightly elevated. Solar wind speed, as observed by ACE at L1, rose from near 300km/s to around 350-400km/s with the CME arrival, then climbing to peak around 450 km/s between 25/0200-0600 UTC before easing back to background, near 350km/s by 25/1200 UTC. Density was mainly at average, but rose to peak 12-14 ppcc at times between 24/1700-1950 UTC. Total Interplanetary Magnetic field (IMF) strength, Bt, also rose to at 24/1617 UTC to be mainly moderate 8-11nT thereafter. The north-south component rose to be moderate, and was variable in direction until 24/1950 UTC, then briefly positive (northward) until 24/2300 UT, then variable but mainly negative (southward) thereafter. Values ranged between +8nT and -10nT. Phi angle was mainly negative (towards from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 2-3).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux was very slightly above normal background levels, but well below the S1/Minor Radiation Storm threshold. Electron flux (greater than 2MeV) observed at GOES16 has been at normal background levels, with electron fluence well below the Active (1e8 integrated pfu) threshold. The observed 24-hour fluence at 25/0000UTC was 9.58e5 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is forecast to be Low to Moderate, with isolated M-class flares likely. There remains a chance of isolated X-class flares from AR3590.

Solar Wind / Geomagnetic Activity: Background solar winds are likely to become enhanced later day 1 (25 Feb), from the onset of the fast wind from CH01/-, before peaking into day 2 (26 Feb). These fast winds easing day 3 (27 Feb). Quiet activity at first becoming Unsettled to Active with a chance of G1 Minor Storms from coronal hole fast wind onset on day 1 or 2 (25-26 Feb). Quiet to Unsettled activity returning day 3 and 4 (27-28 Feb).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux

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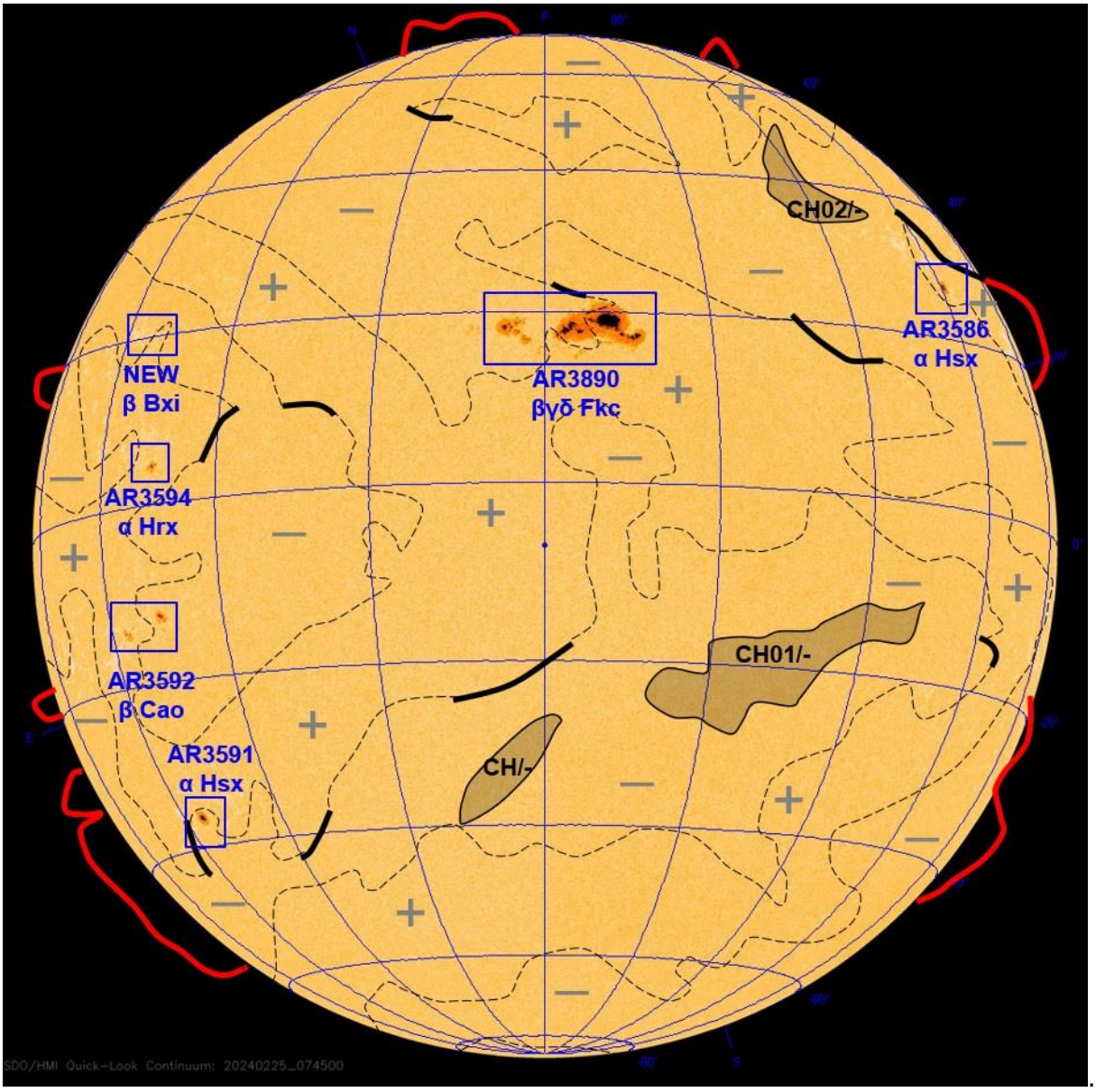
is likely to continue easing near background levels, but with a chance of enhancement due to any significant flares from AR3590, increasing as the region moves into the western hemisphere. High energy electron flux (greater than 2MeV) is expected to persist at background at first. An increase to Moderate or High levels is then possible from late day 2 (26 Feb) onward in response to any solar wind enhancement from the coronal hole fast wind onset. 24-hour electron fluence is expected to stay below the Active (1e8 integrated pfu) threshold, but with a rising trend, giving a slight chance of reaching Active by days 3-4 (27-28 Feb).

Figure 1. Solar Analysis Valid 25/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

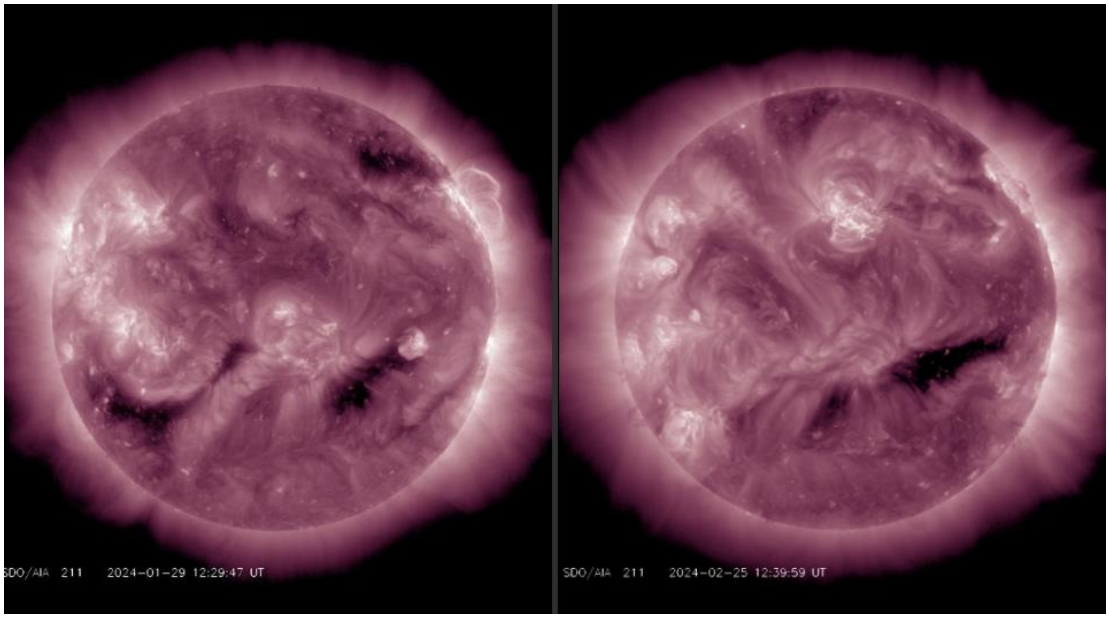
There are no Earth-directed CMEs.

A weak enhancement to the solar wind early on 25 Feb was most likely to be due to ongoing CME effects from the weak glancing arrival on 24 Feb, with winds recently easing to background. The fast wind of CH01/+ is now expected to connect through the next 24 hours, with solar winds rising to 500-550km/s. This coronal hole is both negative, which is favourable for geoeffective enhancements at this time of year (Russell-McPherron effect) and a persistent feature, which both support a relatively strong connection. However, the connection on the previous rotation was subdued, and current MOSWOC enlil only suggests a weak enhancement is likely, reducing confidence. Any coronal hole enhancement is expected to gradually decline day 3 onward (27 Feb) with solar winds easing to background.

Geomagnetic activity is expected to be mainly Quiet with isolated Unsettled spells. However onset of fast winds of CH01/-, either late day 1 or early day 2 (25-26 Feb) will likely bring a spell of Unsettled to Active with a chance of G1 Minor Storm intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	25	25	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: SDO aia-211 of previous (left) and current (right) rotation, showing stronger CH on this occasion.



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Radio Blackouts - X-Ray Flares:

Low to Moderate activity is expected with the ongoing likelihood of isolated M-flares. There remains a chance of isolated X-class flares from AR3590.

There are five numbered regions on the disc and one unnumbered region, however AR3590 dominates the flare risk probabilities. This is a large spot with ongoing slight areal growth situated in the north-centre disc, and was the source of three X-flares on 21-22 Feb, including an X6.3, the largest flare of the solar cycle so far. The region comprises of a large and strong positive polarity leader which shares penumbra with a large negative intermediate spot, leading to a delta configuration, along with a weaker and more broken trailer region. There are a number of other small delta spots visible, including one east of the intermediate spot, however all of these delta-spots, including the main one, are weak due to limited magnetic flux along their parity separation line. There is also limited shear across the spot, due to it being E-W aligned, and a lack of recent activity leads to low confidence for any further significant flares. However, if flaring was to occur, the available flux suggests the potential for further high M, or X-class flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	60	60	60
Very Active	R3 to R5 X Class	No	25	25	20	15

Figure 3a: GOES 16/18 X-ray Flux

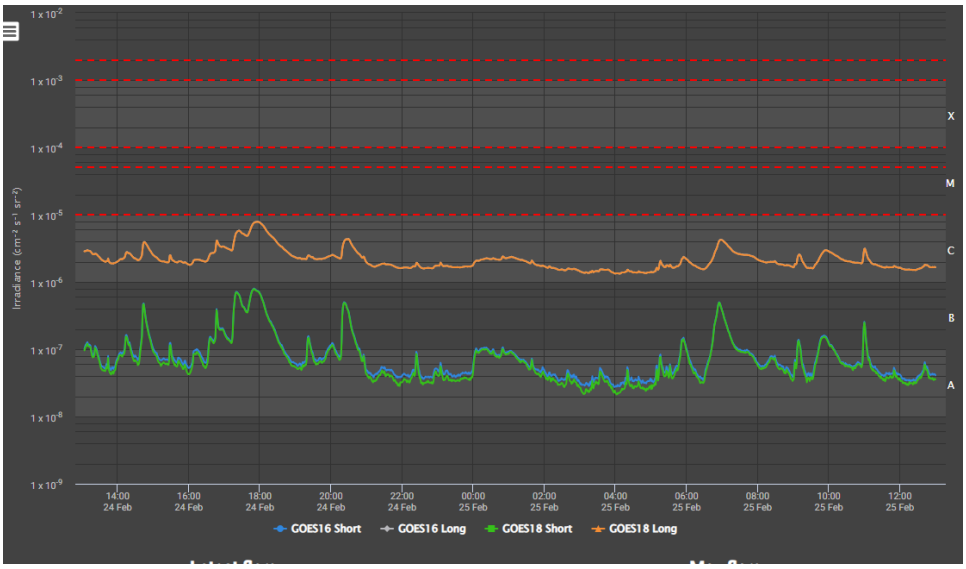

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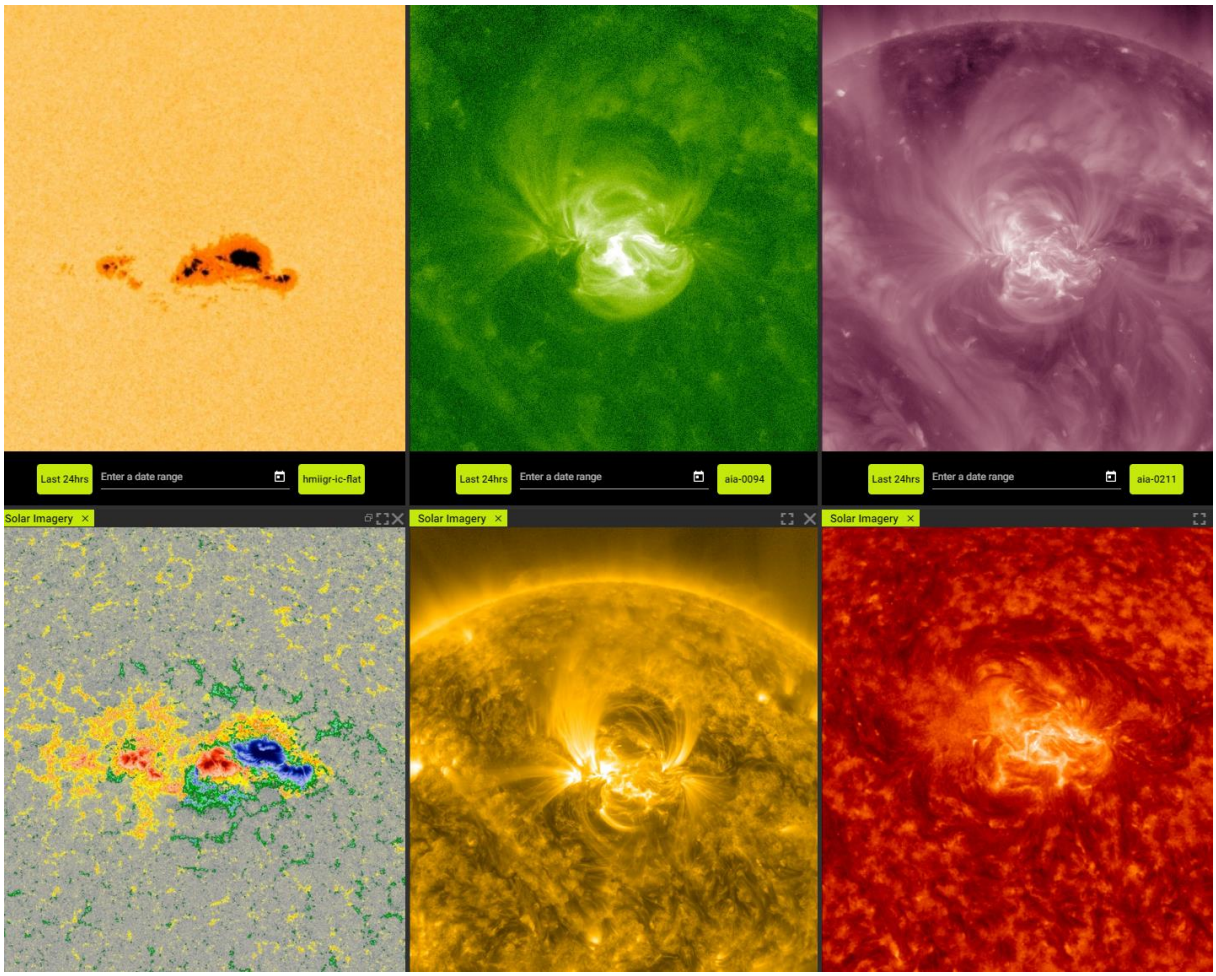
Figure 3b: SDO imagery of AR3590 (Intensitygram, aia-94, aia-211, magnetogram, aia-171, aia-304)



Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux is slightly above normal background levels, but well below the S1/Minor Radiation Storm threshold. The source of this slight enhancement is most likely due to the lingering effects of the increased flux since 09 Feb. The X-flares of AR3590 are unlikely to have contributed.

However, as AR3590 moves across the western disc any further strong flare activity will bring a chance of enhancing the observed proton flux at GEO, especially if those flares are eruptive. This will bring a chance of reaching S1 Minor Radiation storm levels, with a very slight chance of stronger storms being observed (S2+).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	20	20	20
Very Active	**≥ S3 ***	No	1	5	5	5

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES-16 is currently at background. The expected enhancement from CH01/- is likely to increase populations through the Van Allen Belts, however confidence is low with how strong this enhancement will be. Initially observed at lower orbits, any enhanced flux will relax back to GEO through day 2 and day 3 (26-27 Feb), with the observed GOES-16 flux likely becoming Moderate with a chance of reaching High, primarily at diurnal maximum on day 3 or 4 (27-28 Feb).

The associated 24hr fluence is expected to remain below the Active (1e8 integrated pfu) threshold during much of this period, but with a rising trend likely from late day 2 (26 Feb). This will give a slight chance of reaching Active by the end of day 3 (27 Feb). MOSWOC REFM provides good guidance until any coronal hole enhancement occurs.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	15
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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